# Problem Specification

Glass has fast become a very common building material for a wide variety of reasons including cost, safety, and aesthetics (Kathy Velikov, 2012). But there can be problems with its reflective and transmissive properties. Too much glass use creates an issue of allowing or directing sunlight into places where it may not be desirable; either inside or outside the building. This includes issues of excessive heating of the interior or, in some cases, concentrated light scorching a building’s surroundings (Hodge, 2010; Verity, 2013). Fixed and computer controlled window shades are some of the current solutions to these issues, but the goal of this project is to improve upon these solutions. Previous ideas for improvements from designers and architects include work on creating more organic building exteriors. These designs incorporate concepts of organic architecture and biomimicry into the building’s “skin” (Battenbough, 2009). Some of these designs alter the amount of natural lighting (Leach, 2009) while others change airflow (Sung, 2009); all reacting to changes in the environment. These are some of the adaptive architecture concepts upon which our project will be building on.

The goal of this project is to design a simple approach to sensing and obstructing sunlight autonomously – only when it is unwanted. Our clients have provided a basic conceptual solution, the task of this project is to assess from an engineering perspective whether this concept is feasible. Fixed shades permanently block light and obscure sightlines while computer controlled shades often require technicians for installation. The present design is targeted for use in single-family homes where the cost and inconvenience of installation and maintenance make more complex systems less attractive. The main issue faced in this project is determining what would be used to actuate the blinds. Our constraints dictate that the system must be able to independently detect and react to different levels of light throughout the day. The actuator must also have sufficient power to open and close the blinds. This is determined by the power source and the efficiency of the actuators. To reduce the complexity and environmental impact, the preferred solution would not require an external power source. More importantly, a “wireless” system emphasizes the product’s aesthetic appeal of “organic” behaviour. This means the system should be self-powering (solar or some variation). The amount of work required to open and close the blinds must then be equal or less than the expected energy generated for the system to function.

The two actuator solutions proposed by our clients for this project are bi-material and shape-memory actuators. Both of these systems combine temperature sensing with actuation, meaning they are both triggered to actuate by temperature changes. The actuators must then be tuned to create the required displacement to close the blinds on a hot day and to keep the blinds open on a cooler day. The force exerted by these actuators must also be enough to open and close the blinds.

The shades must also be robust enough to function over multiple years without requiring replacement or significant maintenance. It should not degrade under typical environmental conditions. The location of the blinds will have a large effect on what conditions are expected during operation. Our clients would prefer externally installed blinds, but other options will be considered. The harshest conditions would be expected outside and the most controlled conditions would be between the window panes.

The environmental aspect of this project is clear from its original goal and low environmental impact is something we will consider in all aspects of the product. In addition to reducing a building’s energy consumption, our product should also reduce the energy consumed in its materials and assembly.

Finally, our clients have requested an analysis of the cost savings of our system versus traditional air-conditioning cooling systems. We hope to price the product such that the cost savings of the fixture will be attractive.

# References

Battenbough, G. (2009, September 7). Smart materials will "revolutionise" architecture within years: expert. *Architecture & Design*.

Hodge, D. (2010, October 1). Reflective "death ray" torments Vegas sunbathers. *Reuters*.

Kathy Velikov, J. J. (2012). *The Benefits of Glass.* Ann Arbor, Michigan: The University of Michigan Taubman College of Architecture and Urban Planning.

Leach, N. (2009). Digital Morphogenesis. *Architectural Design, Volume 79, Issue 1*, 32-37.

Sung, D. K. (2009). Prototyping a Self-Ventilating Building Skin With Smart Thermobimetals. *AIA Report on University Research - Volume 5*.

Verity, A. (2013, September 3). Who, what, why: How does a skyscraper melt a car? *BBC News Magazine*.